Correlated electron transport in mesoscopic structures

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Focus: Electronic Theory of Nanostructures

Ongoing projects:

1. Quantum coherence in the transport of the electric charge
2. Quantum magnetic properties of nanostructures

Educational effort:

A. Kaminski – graduated with Ph.D., now a postdoctoral associate at the University of Marland;

M. Pustilnik – postdoctoral work at the University of Minnesota, currently a junior faculty at Georgia Tech;

M. Vavilov – postdoctoral work at the University of Minnesota, currently a postdoc at MIT;

I. Ussishkin, M. Houzet – started postdoctoral work at Minnesota this academic year

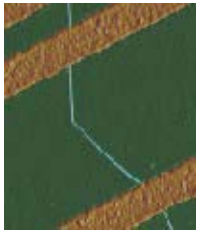
1. Quantum Transport of Electric Charge

New physics at the nano-scale:

- Electric current by transfer of single electrons
- Interference of electron quantum waves

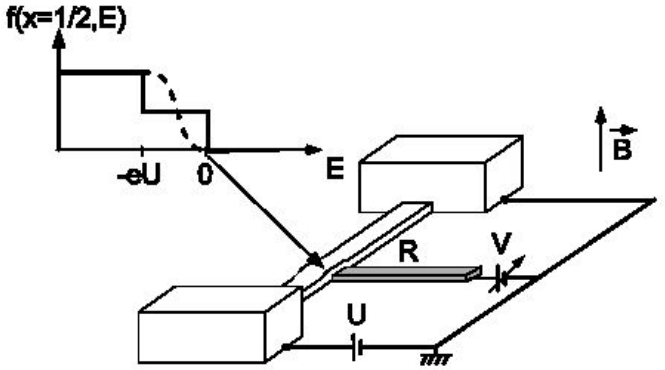
New objects of study:

- Carbon nanotubes



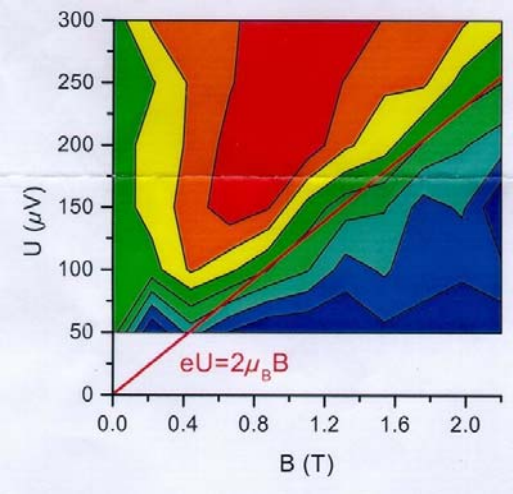
Carbon nanotube (blue) between gold electrodes
[from C. Dekker et al, Science, 2000]

- Metallic nano-wires



Transport of electric charge – new results

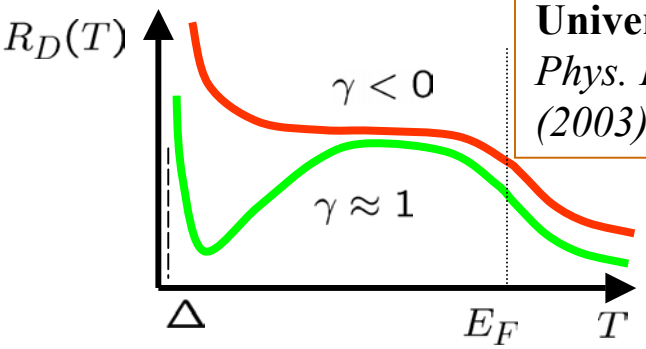
•Explanation of fast electron energy relaxation in metallic nano-wires, prediction of Zeeman effect in the energy relaxation (recently confirmed)



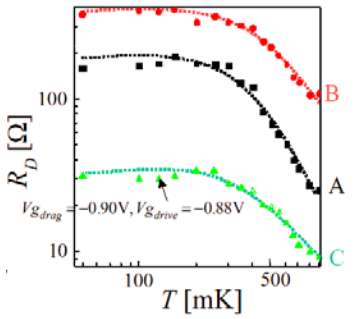
[Experiments: SACLAY (France),
MSU (East Lansing)]

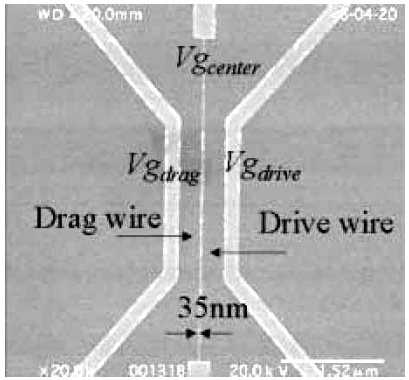
Theory: University of Minnesota
Phys. Rev. Lett. **86**, 2400 (2001)
Phys. Rev. ***B*** **67,** 115310 (2003)
Phys. Rev. ***B*** **68**, 075119 (2003)

•Prediction of the temperature dependence of the Coulomb drag effect in quantum wires



Theory:
University of Minnesota
Phys. Rev. Lett. ***91****, 126805 (2003)*





[Experiments: Tokyo University, Japan]

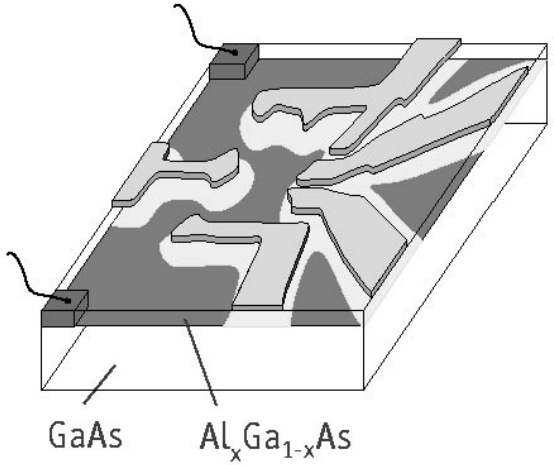
2. Magnetic Properties of Nanostructures

New physics at the nano-scale [**spintronics**]:

- Slow relaxation of single-electron spins
- Spin-sensitive mechanisms of charge transfer

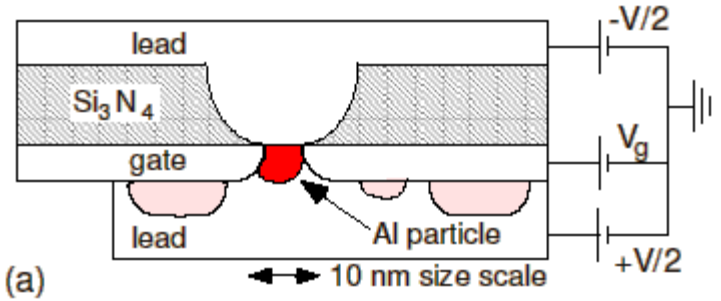
New objects of study:

- Quantum dots in GaAs FETs



[C. Marcus, Harvard University]

- Metallic nanoparticles

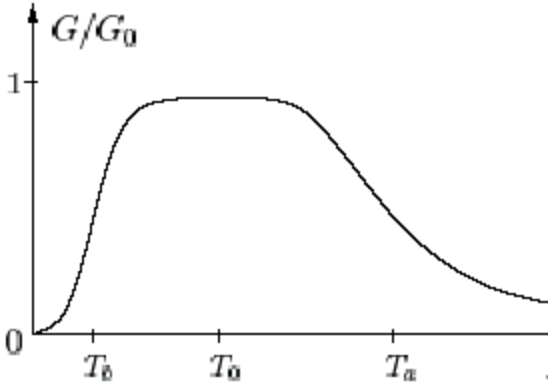


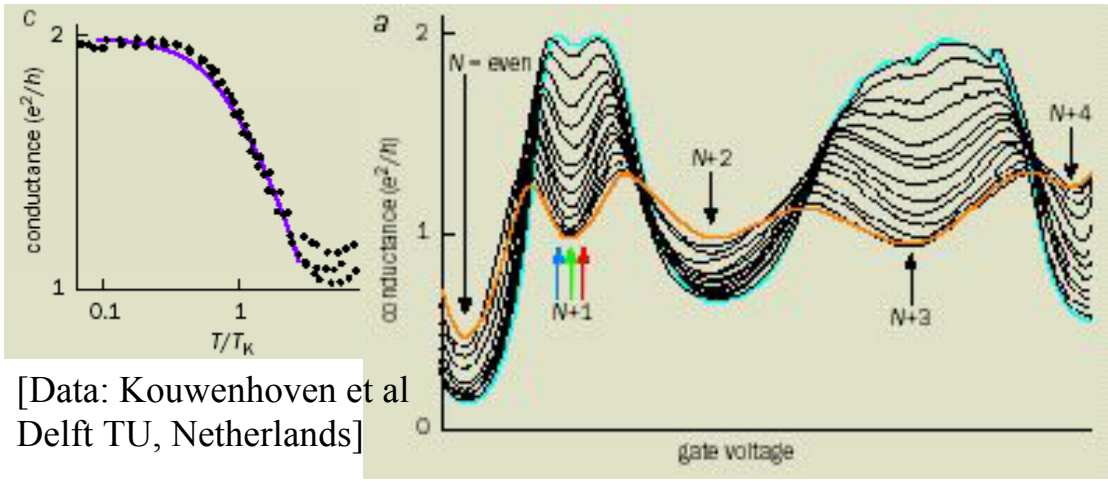
[D. Ralph, Cornell University]

Spins in nanostructures – new results

•Comprehensive theory of Kondo effect in real quantum dots

Theory: University of Minnesota
Phys. Rev. Lett. **87**, 216601 (2001)
Phys. Rev. ***B*** **68,** 161303(R) (2003)





[Data: Kouwenhoven et al
Delft TU, Netherlands]

•Theory of a confined electron spin evolution caused by interaction with nuclear spins

Theory: University of Minnesota
Phys. Rev. Lett. **88**, 186802 (2002)
Phys. Rev. ***B*** ***67***, 195329 (2003)